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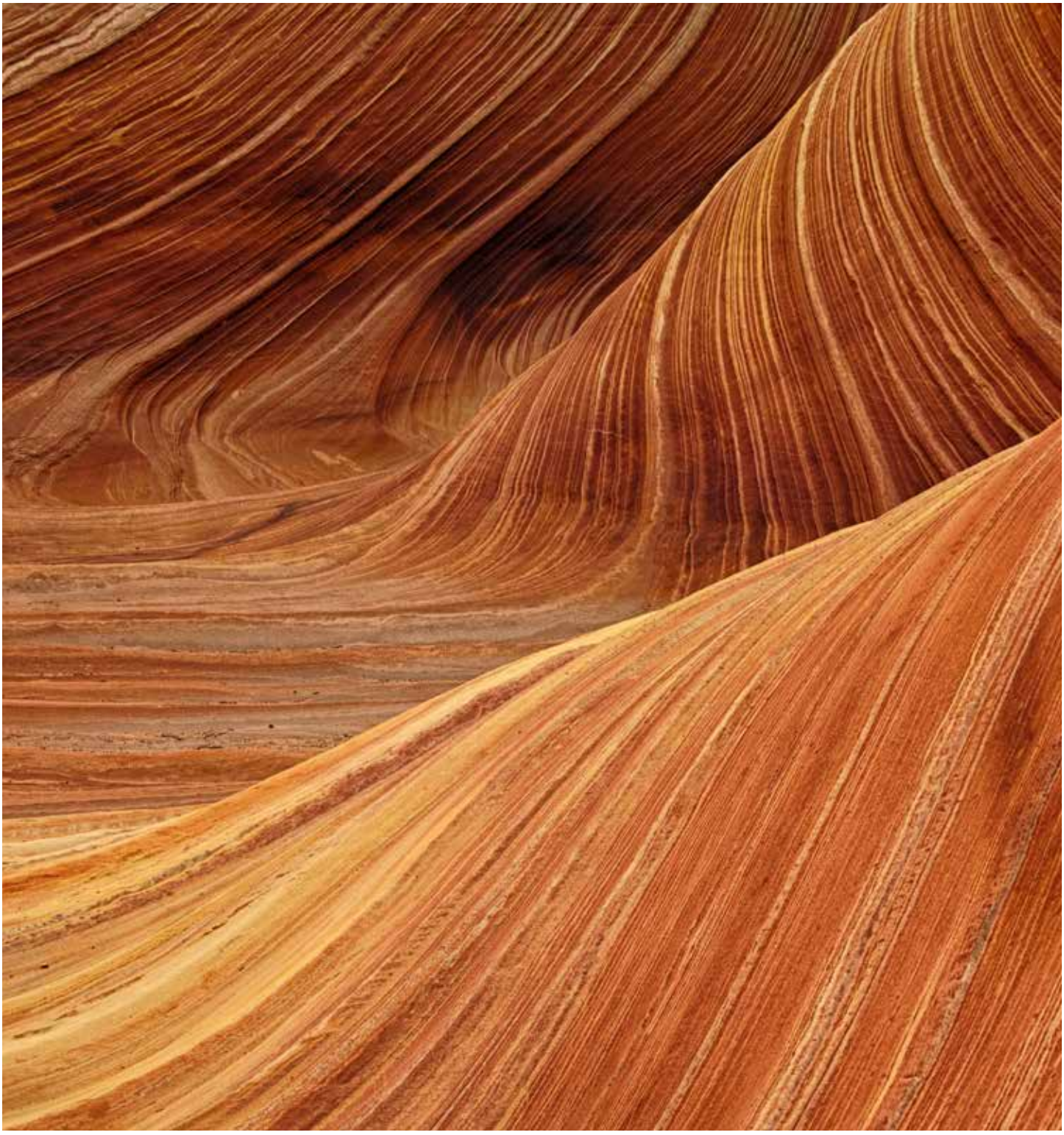

National Council of Supervisors of Mathematics www.mathedleadership.org

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Elementary Mathematics Specialist Program: One State's Story of Development and Implementation

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Abstract

In this paper we present the development and implementation of the Oklahoma Elementary Mathematics Specialist certification pathway. The partnership among mathematics educators from several universities that led to the development and implementation of program requirements and coursework is shared. We also discuss the various challenges we faced throughout this process at the state and local levels. Finally, we provide evidence of the impact of these efforts from interviews of several teachers who completed the program.

Introduction

For the past several decades, Oklahoma has consistently ranked near the bottom of the states (most recently, 48th) for education quality which includes indicators for student achievement (Education Week, 2015). In 2013, the percentage of students in Oklahoma who performed at or above the Basic level on the National Assessment of Educational Progress (NAEP) was 68%, which represented a decrease from 2011, while only 25% of students performed at the NAEP Proficient level. In 2015-16, 43% of Oklahoma's new teachers were alternatively certified or emergency certified, meaning that nearly half of the new teachers had, at most, passed an exam to enter the classroom rather than successfully completed a teacher preparation program (Baines, Hannah, & Wickham, 2016). With this rate increasing each year, it is difficult to assess the mathematics background, not to mention the pedagogical content knowledge, of a significant portion of individuals now teaching mathematics in Oklahoma's classrooms. The need for improvement in education, mathematics teaching and learning in particular, and the need for mathematics leadership at all levels is paramount in our state. With these and similar concerns in mind, the state of Oklahoma began work to develop an Elementary Mathematics Specialist (EMS) certification pathway in 2009. As longtime members of the National Council of Teachers of Mathematics (NCTM) and the Association of Mathematics Teacher Educators (AMTE), we (the authors) were eager for the development and implementation of EMS programs in our state with the sincere hope that such a program could bring about improved mathematics teaching and learning at the elementary level.

We have been engaged in all aspects of the development of Oklahoma's EMS certification pathway, the program requirements, the university coursework (at four institutions), and the certification assessment exam. The development and implementation of the Oklahoma EMS certification pathway is a story of success regarding the program's impact on the participant teachers' leadership capacity, mathematics content knowledge, and pedagogical practices for teaching mathematics (Utley & Reeder, 2016). Unfortunately, it is also a story imbued with challenges related to policy, politics, accreditation, and resources. The purpose of this paper is to share our story of development and implementation of the Oklahoma EMS program. In

doing so, we describe the challenges we encountered and the impacts of the program on the participant teachers' leadership capacity.

Background Literature

Elementary Teachers as Generalists

The need for improved elementary mathematics teaching and learning has long been a concern for the mathematics education community (e.g., Coleman & Selby, 1983; NCTM, 1989; Wu, 2009). Researchers have highlighted the urgent need to provide increased and more effective mathematics instruction at the elementary level (Coleman & Selby, 1983). The issue of improving both the teaching and learning of mathematics in pre-K-6 environments has been the subject of countless research studies focused on teacher content knowledge (e.g., Hill, Rowan, & Ball, 2005; Smith, Swars, Smith, Hart, & Haardoerfer, 2012), teacher beliefs about mathematics teaching and learning (e.g., Campbell & Malkus, 2011), and student learning (e.g., Bronson & Erchick, 2010). Further, the discussion about the need for leadership and specialists in mathematics at the elementary level has been a focus of the mathematics education community for decades (e.g., Dossey, 1984; Fennel, 2006; National Mathematics Advisory Panel [NMAP], 2008; Reys & Fennel, 2003).

The NCTM (2000), the AMTE (2013), the NMAP (2008), and the National Research Council (NRC, 1989) stated that most elementary teachers are generalists. Elementary teachers are prepared in their teacher certification programs to teach all core subjects, and as such, rarely have the opportunity to develop the depth of knowledge nor the skills required to teach elementary mathematics effectively. In the *2012 National Survey of Science and Mathematics Education*, Banilower and colleagues (2013) found that while 77% of elementary teachers surveyed reported that they felt well prepared to teach number and operations, only 56% felt the same when asked about measurement, 54% when asked about geometry, and 46% about early algebra. The cause of this uncertainty was often associated with elementary teachers' lack of preparation in mathematics. The authors of *Everybody Counts* (NRC, 1989) stated that "too often, elementary teachers take only one course in mathematics, approaching it with trepidation and leaving it with relief. Such experiences leave many elementary teachers totally unprepared to inspire children with confidence in their own mathematical abilities" (p. 64). The Conference Board of Mathematical Sciences (CBMS, 2012) added that elementary teachers specifically need a broader and deeper understanding of the mathematics they will teach, and they need to understand how the content they teach connects across topics and grades. With elementary teachers being prepared as generalists, Wu (2009) and the NMAP (2008) suggested that focusing on EMSs' content knowledge could be an alternative to the problem of increasing the content knowledge of all elementary teachers.

Elementary Mathematics Specialist Movement

Since the early 1980s, there have been recommendations for the development of EMSs. At their annual meeting in 1981, NCTM passed a resolution calling for state agencies to development certification credentials for EMSs. Since then, several NCTM presidents (e.g., Dossey, 1984; Lott, 2003; Fennell, 2006; Gojak, 2013) have also described the need for EMSs. Additionally, several seminal publications in mathematics education have called for the development of EMSs (e.g., CBMS, 2001; NCTM, 2000; NMAP, 2008; NRC, 2001). Each of these presidential messages and seminal publications noted the issue of the preparation of elementary teachers as generalists and the need for elementary schools to employ a mathematics specialist. More recently, a joint position statement of AMTE, the National Council of Supervisors of Mathematics (NSCM), NCTM, and the Association of State Supervisors of Mathematics (ASSM) indicated that:

> EMS professionals need a deep and broad knowledge of mathematics content, expertise in using and helping others use effective instructional practices, and the ability to support efforts that help all pre-K-6 students learn important mathematics. [Mathematics should focus] on mathematics content knowledge, pedagogical knowledge and leadership knowledge and skills. (para. 1)

Despite the longstanding concerns about the teaching and learning of mathematics at the elementary level, the formalization of pathways to develop EMSs is recent with pathways for EMS certification or endorsement established in only about twenty states (EMS & Teacher Leader Project, 2016; Rigelman & Wray, 2017). In 2010, with the support of ASSM, NCSM, and NCTM, and after considerable development, AMTE released their *Standards for Elementary Mathematics Specialists: A Reference for Teacher Credentialing and Degree Programs* (2010/2013). In this

document, AMTE proposed that curriculum for the preparation of EMSs include content knowledge for teaching, pedagogical strategies for teaching, and leadership knowledge and skills.

Roles of Elementary Mathematics Specialists

Reys and Fennel (2003) defined EMSs as "teachers with particular knowledge, interest, and expertise in mathematics content and pedagogy" (p. 278). Although there are currently numerous programs for preparing EMSs across the nation, the preparation and the role that EMSs fill in schools varies significantly. These individuals may carry a variety of titles such as mathematics or instructional coach, mathematics interventionist, or elementary mathematics specialist. Swars, Smith, Smith, Carothers, and Myer (2016) revealed that EMSs' roles have been viewed from a variety of perspectives resulting in EMSs working primarily with students, teachers, or both students and teachers depending on context and need. The various roles that EMSs may inhabit in schools or districts played a significant role in the design of the Oklahoma EMS certification pathway.

EMSs may teach mathematics to students in one or more grades, provide remediation or enrichment for groups of students, or serve as instructional coaches at the school or district level (AMTE, ASSM, NCSM, & NCTM, 2013). In all of these roles, EMSs will typically provide support for teachers in their building or district through a variety of activities such as modeling lessons, providing resources and professional development, co-planning, co-teaching, analyzing student data, and developing curriculum.

> [Regardless of] the setting or responsibilities, EMS professionals need (1) deep and broad understanding of mathematical content, including the specialized knowledge needed for teaching, (2) solid knowledge of the elementary context, (3) expertise in using and helping others use effective instructional and assessment practices that are informed by knowledge of mathematical learning trajectories, (4) knowledge and skills for working with adult learners, and (5) leadership skills necessary to influence and support educational efforts to improve the teaching and learning of mathematics. (AMTE, ASSM, NCSM, & NCTM, 2013, p. 1)

Oklahoma's Elementary Mathematics Specialist Certification Pathway

In the state of Oklahoma, there are four main agencies (not including the Oklahoma State Senate and House of Representatives) that are involved in and govern matters related to teacher certification and licensure. The Oklahoma State Regents for Higher Education (OSRHE) and the Oklahoma State Board of Education (OSBE) along with the Oklahoma State Department of Education (OSDE) and the Oklahoma Education Quality and Accountability Board (OEQA) govern certain aspects of teacher certification. Since the EMS certification pathway in Oklahoma was developed as an add-on certification for teachers who have an undergraduate degree and are certified teachers, the work related to the development of EMS fell under the auspices of the OSRHE. Thus, in 2009, amidst the backdrop of the national discussion and effort focused on the important role of EMSs, the OSRHE formed a committee of teachers and university mathematics educators to begin development of the Oklahoma EMS certification pathway.

Standards Development

In 2010, following the release of AMTE's standards for EMSs, members from the Oklahoma team were invited to and attended the first States Certification Conference for Elementary Mathematics Specialists in Louisville, Kentucky supported by the Brookhill Institute of Mathematics. Shortly following that meeting, Oklahoma began the process of developing standards as well as the structure and criteria for the Oklahoma EMS certification program.

Rather than adopting the standards developed and vetted by AMTE, the OSRHE determined that Oklahoma should develop its own standards. This decision was consistent with past decisions by the state to develop its own versions of standards and teacher certification exams rather than use those that had been nationally developed and adopted by other states. Work to develop the Oklahoma EMS standards began in earnest in 2010 and involved the efforts of nearly 30 mathematics educators and teachers from universities, colleges, and school districts across the state of Oklahoma along with representatives from the OSRHE and the OSDE. Following months of development, the final draft of the Oklahoma EMS standards received input by education constituents and were reviewed by two independent national reviewers. In early 2012, the Oklahoma EMS standards were approved by the OSBE.

Program Requirements

During the standards-development process, efforts were coordinated among the OSRHE and the OSDE. The OEQA regulates the process for obtaining an Oklahoma EMS certification as well as the accreditation for universities offering the program. The group of mathematics educators and teachers working to develop the standards made the following recommendations for program candidates, institutions, and coursework requirements that were approved and adopted by the OSRHE and OEQA.

Candidate Requirements – must be met prior to beginning coursework:

- Valid teacher certification in Elementary Education and/or Early Childhood Education; and
- Two years of full-time teaching experience in grades pre-K through 5 at an accredited school under a valid state-issued teacher credential.

Institution Requirements:

- A state approved and/or nationally accredited Elementary Education or Early Childhood program.
- Regents' approval is required for state institutions offering the Oklahoma EMS coursework leading to a new master's degree as a Mathematics Specialist. Approval is not required if the coursework is an option for an existing master's level program. Or, governing body approval is required for private institutions.

Coursework Requirements:

- Eighteen hours of graduate level coursework is required. Institutions will determine the coursework for a candidate to satisfy the Oklahoma EMS competencies. . . . Criteria for the 18 hours are 60-70% focus on pedagogical mathematics content knowledge and 30-40% mathematics instructional leadership (see Figure 1).

Once the criteria for the coursework were approved and the standards adopted, universities were free to develop and implement the coursework required for the EMS program.

FIGURE 1.

Oklahoma EMS program content and pedagogy requirements

Domain No.	Domain Title	Credit Hours
I	Number Concepts and Operations	60-70%
II	Algebra and Functions	
III	Geometry and Measurement	
IV	Data Analysis and Probability	
V	Mathematics Instructional Leadership	30-40%
Total (%)		100%
Total (Credit Hours)		18

Our Vision for EMS Certification Programs in Oklahoma

The state of Oklahoma has an expansive university and college system including two large research universities, six regional universities, and numerous state-funded colleges, community colleges, and private colleges. We are both mathematics educators at the research universities (University of Oklahoma and Oklahoma State University) and have been involved in the Oklahoma EMS work since it began in the state. Additionally, we also attended AMTE pre-conference workshops with Francis "Skip" Fennell (former NCTM President and Director of the Elementary Mathematics Specialists and Teacher Leaders Project) in anticipation of developing the coursework for the certification program. We were eager for the Oklahoma EMS programs to be strong and credible and knew that our colleagues at the regional universities planning to offer this program would agree.

Oklahoma Mathematics Educators Partnership

Considering our desire to develop strong EMS programs in the state and recognizing that there were only one or two mathematics educators at each university, we formed a group that ultimately included the two of us and a mathematics educator from each of two regional universities. The purpose of this partnership was to provide support for one another in the envisioning and development of 18 hours of graduate coursework and other program requirements. In addition to having attended EMS workshops at

AMTE annual conferences, we also contacted colleagues from across the nation who had successful EMS programs and asked if they might be willing to share their syllabi and other program information.

Our small group began meeting in summer 2012 to develop the course syllabi, portfolio requirements, and field experience expectations. Using the course syllabi shared with us from the North Carolina university system, these conversations and work sessions were robust and motivated by the hope and belief that implementing EMS programs in Oklahoma could create significant change for mathematics teaching and learning at the elementary level. We believed then, and still do, that developing EMSs is an answer to address many of the profound challenges we face in improving mathematics teaching and learning at the elementary level.

After many hours of meetings in people's homes over the summer and working digitally between the meetings, we developed several key goals for our EMS program and ideas about how we would meet those goals through six graduate-level courses. We decided five courses would be content and pedagogy focused, and one would be focused on leadership development. In addition to coursework discussions, we determined that the program would be comprised of essential assignments to be repeated throughout each content/pedagogy course with a change in the mathematical content focus (e.g., teachers would develop and locate high cognitive demand tasks and develop a literature review in each course). In addition, a list of other program activities and experiences was developed. We also created a portfolio assignment to provide an opportunity for teachers not only to display the essential assignments from the program but also to document the other required experiences and activities they should accomplish by the end of the program (e.g., submit a grant application for materials for their classroom, develop and present a professional development session for teachers in their building, or mentor a new teacher in their building specifically focused on the improvement of mathematics teaching and learning). Finally, considerable time and thought was given to developing meaningful and appropriate expectations for the 30-hour field experience required for the program by the state guidelines. We determined that the field experience would be best embedded in the leadership course. Given that the teachers in the program would all be practicing classroom teachers, a menu of items/experiences was developed to help them meet the 30-hour expectation (e.g., observe an expert elementary mathematics teacher in another building/district, lead a group of teachers in their building in a book discussion, or work with a group of students not in their class on mathematics for intervention or improvement).

Consideration of the goals and aspirations of the OEMS program to develop elementary mathematics leaders whose content and pedagogical knowledge would be deepened and strengthened led to the development of six courses focused on the following main topics and ideas*:

- Algebra and Mathematical Tasks;
- Geometry, Spatial Visualization, and Learning Trajectories;
- Data Analysis, Measurement, and Instructional Technology;
- Number Concepts and Assessment;
- Rational Number Concepts, Proportional Reasoning, and Classroom Interactions; and
- Mathematics Leadership and Coaching (includes a minimum of 30 hours of field experience).

*Course titles vary to some degree from institution to institution.

Each course, with the exception of the leadership and coaching course, focused on certain mathematics content paired with a pedagogical practice or aspect of effective mathematics teaching. To meet both the content and pedagogical goals and objectives for each course while also keeping the goals and aspirations of the program related to content, pedagogy, technology, and leadership in mind, considerable thought was given to how best to engage teachers in each course. For example, the course focusing on geometry, spatial visualization, and learning trajectories included the following goals and objectives for both content and pedagogy:

Content-focused outcomes:

1. Demonstrate content knowledge in K-8 geometry based upon national standards (i.e., Common Core State Standards for Mathematics and National Council of Teachers of Mathematics).
2. Describe geometric shapes and properties, location, transformations, and spatial relationships/visualization.

3. Understand the relationship between two-dimensional and three-dimensional shapes, perimeter and surface area, and area and volume.

Pedagogy-focused outcomes:

1. Compare and contrast various mathematics pedagogies for teaching geometry and spatial visualization.
2. Explain a variety of appropriate teaching methodologies for mathematics.
3. Use appropriate technology to support student learning of geometry and measurement.
4. Evaluate and analyze student thinking using the van Hiele Levels of Geometric Thinking.
5. Evaluate and identify a variety of appropriate instructional strategies to assist elementary children in developing an understanding of geometric concepts.
6. Identify and describe the learning trajectories for mathematics for pre-K through 6th grade students.
7. Compile different assessment strategies that will measure student learning and understanding as well as inform teacher decision making.
8. Identify the ways to help students connect the geometry and measurement content they are learning to their existing mathematical knowledge, to other disciplines, and to their world.

When our group considered the experiences we wanted for the teachers in this program related to content, we heeded the CBMS (2012) calls for change in how teachers of mathematics are prepared. They suggested:

> A major advance in teacher education is the realization that teachers should study the mathematics they teach in depth, and from the perspective of a teacher. There is widespread agreement among mathematics education researchers and mathematicians that it is not enough for teachers to rely on their past experiences as learners of mathematics. It is also not enough for teachers just to study mathematics that is more advanced than the mathematics they will teach. Importantly, mathematics courses and professional development for elementary teachers should not only aim to remedy weaknesses in mathematical knowledge, but also help teachers develop a deeper and more comprehensive view and understanding of the mathematics they will or already do teach. (p. 23)

Continuing with the example of the course focused on geometry and learning trajectories, we aimed to engage the teachers in our program in geometry content relevant to the mathematics they teach and help them develop a deeper and more comprehensive understanding of that mathematics. In order to meet these goals and objectives, the course was designed to engage teachers in mathematics problem solving each week using problems and activities from Serra's (2002) *Discovering Geometry* (3rd edition) textbook. Throughout the semester, we planned for the teachers in this course to work several problems assigned from the text outside of class to be discussed the following week in class. We developed a list of web sources that would aid the teachers in understanding the content and/or refresh their memory of the particular topic if we did not have enough time to address each concept in class. Given that most teachers in these courses would have experience with the mathematics content presented in our courses, it was important to us that we not spend considerable time teaching mathematical concepts as if they were new to the teachers but rather consider ways to refresh, deepen, and expand the teachers' mathematics content knowledge. To meet this aim, careful thought was put into the pedagogical tasks that would be utilized in class as well as the readings focused on pedagogic practices.

The pedagogically focused materials and activities were purposefully selected in order to support teachers in not only improving their teaching practice but also developing their understanding of key mathematics concepts. The use of Quickdraw (Wheatley, 2007) provides a specific example. Quickdraw images would be used on a regular basis throughout the course to model for teachers how to utilize them as an effective classroom opener to develop their own students' spatial sense, definitions of a variety of shapes, and understanding of characteristics and classifications of a variety of shapes. Further, teachers would experience how quickdraw images can aid in the development of sociomathematical norms (Yackel & Cobb, 1996) that include communicating, listening, and honoring other's perspectives in mathematics class. Beyond learning how quickdraw images can be used with their own students, however, the plan for their use in our classes would be to develop many of those same understandings with and for our teachers. In this way, the use of quickdraw images can help to model and teach effective pedagogical practices while also deepening and extending the teachers' mathematical understanding and helping to develop their spatial sense. Since the pedagogical focus of this course was

learning trajectories, not all work with learning trajectories would be focused on geometry concepts, but an emphasis on geometry would be utilized when possible to help support the teachers' understanding of geometry mathematical content.

Several texts were selected for use across all courses. The readings from those texts were organized so that they were applicable to the course, and so that by the end of the program, teachers would have read the entirety of the text. For example, in the geometry and learning trajectory focused course mentioned previously, both *Math Matters: Understanding the Math You Teach, grades K-8* (2nd Edition) by Chapin and Johnson (2006) and *Learning and Teaching Early Math: The Learning Trajectories Approach* by Clements and Sarama (2009) were used. Teachers would read most of the learning trajectories text for this course but then return to it throughout all other courses in the program as they developed tasks for their students. In contrast, readings and activities from the *Math Matters* text were selected as they related to each course. As such, the teachers would utilize the *Math Matters* text in each content- and pedagogy-focused course in the program. Developing teachers' use of technology was handled similarly. Teachers would be required to purchase *Geometer's Sketchpad* in the first course and then, when applicable, purchase accompanying books with explorations related to the content focus in some of the other courses.

The leadership course was designed as a culminating experience for teachers in the program and as such, four of the five content/pedagogy courses would be required for teachers prior to taking the leadership course. As our group planned for this course, we thought about not only the readings that would expand our teachers' understandings of what it means to be a teacher leader and how to work effectively as an elementary mathematics specialist in a variety of roles, but also about the experiences that would help the teachers develop as leaders in various capacities. Although teachers would be working throughout the program to accomplish the various experiences and leadership tasks provided for them at the onset of their first class, the leadership course would be the place and time that those experiences would culminate. For example, teachers could choose to present at the annual conference for the Oklahoma Council of Teachers of Mathematics (OCTM) but would be required to present a professional development session for teachers in their building. Since we face tremendous funding challenges in our state, teachers would be required to explore grant funding possibilities and apply to combat the common refrain, "We do not have math manipulatives." If teachers had not accomplished this expectation prior to the leadership course, it would be required to be completed by the end of the leadership course. Teachers would document these accomplishments and experiences in their portfolios.

As the group began to pull these ideas together in the form of syllabi and course materials we utilized Dropbox™ to aid in the process. Additionally, we successfully worked to implement the programs at more than one of our universities so that we could launch them at the same time and offer the same courses in the same semester thus supporting continued collaboration. This concurrent implementation of the programs was incredibly beneficial. Offering the courses simultaneously allowed us to remain in relevant conversation via phone and digital meetings throughout the program implementation and help one another as the courses unfolded and unforeseen challenges and concerns arose.

Challenges

Throughout the development and implementation of the OEMS certification pathway and programs, we were met with numerous challenges that are worth mentioning. From the decision by the OSRHE to have us develop our own standards to the limited resources for recruiting and incentives for teachers to pursue the EMS certification, this process was wrought with challenges that have left us almost a decade later asking how do we sustain these programs and how do we move forward.

In our opinion, the decision by state entities to develop standards for Oklahoma rather than simply adopting AMTE's *Standards for Elementary Mathematics Specialists: A Reference for Teacher Credentialing and Degree Programs* (2010, 2013) presented the first challenge in this process. Developing standards is arduous and time consuming, particularly when those standards will be the basis for a summative certification exam. Because we have several entities involved in teacher certification in Oklahoma, the development of the standards was led by the OSRHE, but the development of the certification exam was under the auspices of OEQA. The fact that different entities oversee different aspects of teacher certification naturally creates an opportunity for challenges with communication and that was certainly the case in this process. Additionally,

since OEQA was not involved in the standards-writing process, there was not as much consideration given to the fact that the standards would provide the parameters for the certification exam. If that had been an integral part of our discussions while developing the standards, we suspect that we might have developed a slightly different document.

The final challenge, or perhaps frustration, related to our development of standards for Oklahoma was the fact that there is policy in Oklahoma that indicates that when a national education organization develops standards for a certification area we must defer to those standards. So, amidst our work with EMS candidates in our programs, with all coursework aligned to the Oklahoma EMS standards, NCTM released accreditation standards for EMS programs. At that point, all universities in Oklahoma were required to submit an accreditation report aligned to the NCTM EMS standards for advanced programs even though our programs were not developed to meet the NCTM/Council for the Accreditation of Education Preparation (CAEP) standards (2012). This policy is enforced by the OEQA. Despite our discussions with them regarding the fact that the Oklahoma EMS certification pathway is an add-on certification (18 hours of graduate coursework) and not an advanced certification (typically hours equivalent to a master's degree) we have not gained traction with the idea that trying to meet the NCTM EMS standards for advanced certification is not appropriate for our programs. This immediate deference to the NCTM CAEP standards also brings us back to our original challenge in this process – why did we not simply adopt the AMTE EMS standards in 2009? Due to the requirement that all Oklahoma EMS programs meet accreditation standards set forth by NCTM, no EMS program in the state received accreditation recognition following the first submission of accreditation reports. Although this was incredibly disappointing and concerning for sustainability, it was not surprising since the programs were not developed to meet the NCTM EMS standards and the certification exam was aligned to the Oklahoma EMS standards.

Recruitment and sustainability have been an ongoing challenge throughout this process due to several factors and surprises. First, during the development of the standards, there was much discussion with the OSRHE and OSDE regarding incentives and legislation regarding the addition of EMSs in our state. A tremendous amount of hope for these programs was placed on the idea that the OSDE and other entities would work together to incentivize this certification for teachers. For example, we discussed at length the need for stipends to support teachers pursuing this certification, that schools would be required to offer additional pay for individuals working with this certification, and that schools could only fill their mathematics support positions with individuals who had the EMS certification or were working towards the certification. Additionally, since our EMS certification programs were designed to develop individuals who could work in a variety of EMS roles, we imagined that many teachers would remain as classroom teachers after becoming an EMS so we discussed at length the idea that teachers of fourth- and fifth-grade mathematics be required to attain this certification. At the time, concerns about meeting the expectations of the Common Core (Common Core State Standards Initiative, 2010) was a tremendous motivator for consideration of departmentalization of fourth and fifth grade for mathematics so this seemed like a reasonable expectation for those teachers. This discussion occurred primarily during the standards and program expectation development process with OSRHE with OSDE representatives in the room. Unfortunately, that strong recommendation from the mathematics educators and teachers in the state was not considered or communicated to the OSDE for consideration.

When the development of all aspects of the programs was complete and universities were ready to implement the coursework, we were left with many failed promises. There were no financial incentives for teachers to pursue the EMS certification. No state level entity followed through with a stipend for teachers to pursue the certification. There was no expectation that teachers who work as mathematics support personnel be required to have the EMS certification. There was no additional pay for teachers with EMS certification. There was no discussion regarding departmentalization of fourth- and fifth-grade mathematics. The work of recruiting and promoting the EMS certification fell completely to the university mathematics educators.

Recruiting began for programs at six universities in Spring 2012 immediately following the approval of the Oklahoma EMS standards. One university planned to offer all coursework online while the others planned to offer all coursework in a face-to-face format. All four universities described earlier who collaborated to develop program coursework offered all coursework in a face-to-face format. The initial response to recruiting in terms of teacher interest was overwhelming. Based on interest alone, it

seemed that we would have more teachers eager to begin the programs than we could handle. Unfortunately, that was ultimately not the case. Both of our universities had to postpone the kickoff of our programs due to low enrollment numbers. All those interested teachers had heard that there would be incentives associated with this certification and with the coursework. Sadly, initial interest in the EMS programs waned when teachers realized there would be no financial incentives tied to the certification or coursework. The University of Oklahoma had only eight teachers in the first class while Oklahoma State University had 12 in its first class. Given there were no stipends offered by the state for teachers pursuing this certification, both of us worked with our universities to have something to offer teachers by way of financial help. At the University of Oklahoma, we secured donor funding so each teacher could have a small stipend to help cover tuition for the first three semesters and at Oklahoma State University teachers interested in applying the 18 hour of EMS coursework towards a master's degree were eligible to apply for the TEACH grant. Although the programs got off the ground slowly in 2013, to date five universities have offered the program with approximately 30 teachers having been credentialed as EMSs.

Impact of Program

Given that the development of EMS programs is still a relatively new enterprise in a majority of states, more research on the impact of EMSs is needed (de Araujo, 2015). Although scant, the research available reveals that EMS programs and EMSs have a positive impact on teachers and students (Utley & Reeder, 2016; Campbell, 1996; McGatha, 2009; Polly, 2012). Several studies have found improvements in mathematics teaching and learning related specifically to an increased focus on problem solving and reasoning, use of formative assessment to guide instruction, effective planning, and student achievement because of EMSs' work in schools (Brosnan & Erchick, 2010; Campbell, 1996; Campbell & Malkus, 2011; McGatha 2009; Race, Ho, & Bower, 2002). Our research has shown that the Oklahoma EMS program had an impact through developing teachers' understanding of teacher leadership, increasing teacher leadership activity, deepening and extending teachers' mathematics content knowledge, and improving teacher confidence in their mathematical understanding (Utley & Reeder, 2016).

The EMSs from our programs attest to the impact of the program on their mathematics understanding and content knowledge as well as their pedagogical practices. When asked if the Oklahoma EMS program had impacted her as a teacher, one teacher shared:

> I just believe in the program so much because not only has it changed my math teaching, but it has also changed the way I teach across the board. Just questioning and asking kids instead of just telling. It's changed my whole philosophy. . . I think the biggest thing is that I feel like a new teacher. I feel it has rekindled my passion and rekindled my excitement. At this point in your career, when you have only about 10 years left, that's a big deal. . . I love teaching and I love students, but I'm not too happy with the status quo. I'm out there trying to learn, and I'm out there still feeling like there is more. Before I thought that I had it right. I thought I was doing everything I was supposed to do. I was doing it. I was doing it every day. Now it's like there's more. There's more.

Another teacher discussed her better understanding of productive struggle for her and her students.

> I definitely felt productive struggle several times and I realized productive struggle is okay and it's necessary and I need to allow students to have that. But there is a balance and I think that . . . I've been working with a teacher right now who hasn't found that balance yet. Her kids leave her classroom totally frustrated.

Finally, a third teacher shared her thoughts about how the program impacted her as a teacher.

> There is [*sic*] so many things that I have changed. For instance, I've started to try things like differentiated instruction and come up with activities for the different levels and abilities of my students. I feel like I'm more aware of how children learn and what they need to learn and how they need to learn it and what's more important in teaching them math. . . . So, I'm more aware of what they need to know in the long run to help them understand math, to really know math. I want them to really know it, not just know the steps.

These teachers' testaments to the impact of the program on their teaching and work with students and other teachers is consistent with all the teachers who have completed our programs to date. Although this is anecdotal evidence, it is evidence nonetheless that these 18 hours of graduate credit developed to prepare EMSs in Oklahoma have had a powerful

impact on the teachers involved and have empowered them to work as elementary mathematics leaders in our state.

Concluding Remarks

We agree with Wu (2009) that the way to improve the mathematics teaching and learning at the elementary level in our state is to develop a cadre of teachers who have an interest and expertise in mathematics content and pedagogy. Ball, Hill, and Bass (2005) suggested that little will improve with student mathematics achievement unless significant attention is given directly to the practice of teaching mathematics and the development of teacher content knowledge needed for teaching mathematics. We believe that EMS programs can meet both these expectations. Gojak (2013), a past NCTM president, shared several reasons why the mathematics education community should continue to support EMSs in schools. Among these reasons was the idea that EMSs could impact professional learning communities by providing professional development for teachers focused specifically on teachers' interests and needs. She also suggested that EMSs in schools can help meet the needs of diverse learners and would have the pedagogical and mathematical knowledge necessary to help children develop deep and flexible understandings of mathematics.

Despite the challenges we faced throughout the program development and implementation, we believe, now more than before we began in 2009, that the EMS certification programs in Oklahoma hold tremendous promise. Our program, as outlined in this paper, represents one model for delivering a specialized program for the development of EMSs. Certainly, more research is needed on how best to deliver such programs and on what content is most effective and necessary (de Araujo, 2015). However, even without empirical evidence of the impact of our programs at this stage, the anecdotal evidence is strong in the words of our state's EMSs. Many of them have been transformed from strong classroom teachers in their building and district to elementary mathematics leaders in our state. From among the first small group of teachers who completed our programs, several present every year at the OCTM conference, several provide professional development specifically for elementary mathematics across the state, several work as EMSs in their buildings, and several now run social media sites that support professional learning communities both locally, in the state, and beyond. We believe these programs developed "teachers with particular knowledge, interest, and expertise in mathematic content and pedagogy" (Reys & Fennell, 2003, p. 278), who will work as teacher leaders in their classrooms, their buildings, their districts, and our state, to bring about change in the way mathematics is taught and learned at the elementary level. Further, each EMS reported throughout the program coursework that their work with students was improved as they implemented teaching practices that reflected what they were learning in the program.

We will remain steadfast advocates for these programs but sadly, due to failed promises related to incentives and policy changes to support the EMS programs in our state, the few mathematics educators (and their universities) in our state are left alone to shoulder the investment needed for the continued preparation of EMSs. This leaves us with several important questions about how to sustain the important endeavor of developing EMSs in our state and nation: How do we best recruit and encourage elementary teachers to pursue the EMS certification? If we believe that developing EMSs in our state is key to significant change for the mathematics teaching and learning of children in our state, how do we rally the education entities in our state to help us move forward? Are there ways that mathematics educators and school mathematics leaders in the nation working on and in these programs can support one another around issues of advocacy for elementary mathematics teaching and learning? Although our story of development and implementation of the Oklahoma EMS program was laced with challenges, we overcame many of them and developed several EMSs who are now providing much needed leadership in our state for elementary mathematics. The worthwhile and significant work of developing EMSs will continue in our state, and perhaps we can find ways to work together and support one another across the nation to address the challenges that remain. ✪

References

Association for Mathematics Teacher Educators. (2010/2013). *Standards for elementary mathematics specialists: A reference for teacher credentialing and degree programs.* San Diego, CA: Author.

Association of Mathematics Teacher Educators, Association of State Supervisors of Mathematics, National Council of Supervisors of Mathematics, & National Council of Teachers of Mathematics. (2013). *The role of elementary mathematics specialists in the teaching and learning of mathematics.* Retrieved from https://amte.net/group/resources/12-13/position-role-elementary-mathematics-specialists-teaching-and-learning-mathema

Baines, L., Hannah, J., & Wickham, A. (2016). *Alternative teacher certification: An update.* Paper presented to the Oklahoma State Legislature. October 4, 2016.

Ball, D. L., Hill, H. C., & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach mathematics and how can we decide? *American Educator, 29*(3), 14 - 22.

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 National Survey of Science and Mathematics Education.* Chapel Hill, NC: Horizon Research, Inc.

Brosnan, P., & Erchick, D. (2010). Mathematics coaching and its impact on student achievement. In the *Proceedings of the Psychology of Mathematics Education – North America.* Columbus, OH: PME-NA.

Campbell, P. (1996). Empowering children and teachers in the elementary mathematics classrooms of urban schools. *Urban Education, 30*, 449–475.

Campbell, P. F., & Malkus, N. N. (2011). The impact of elementary mathematics coaches on student achievement. *The Elementary School Journal, 111*, 430-454. doi: 10.1086/657654

Chapin, S. H., & Johnson, A. (2006). *Math matters: Understanding the math you teach, grades k-8* (2nd ed.). Sausalito, CA: Math Solutions.

Clements, D. H., & Sarama, J. A. (2009). *Learning and teaching early math: The learning trajectories approach.* New York, NY: Routledge.

Coleman, W. T., & Selby, C. C. (1983). *Educating Americans for the 21st Century: A plan of action for improving mathematics, science and technology education for all American elementary and secondary students so that their achievement is the best in the world by 1995.* Washington, DC: National Science Foundation.

Common Core State Standards Initiative. (2010). *Common core state standards for mathematics.* Washington, DC: National Governors Association Center for Best Practices and the Council of Chief State School Officers.

Conference Board of the Mathematical Sciences. (2001). *The mathematical education of teachers.* Providence, RI and Washington, DC: American Mathematical Society and Mathematical Association of America.

Conference Board of the Mathematical Sciences (2012). *The mathematical education of teachers II.* Providence, RI and Washington, DC: American Mathematical Society and Mathematical Association of America.

de Araujo, Z. (2015). The need for research into elementary mathematics specialist preparation. *Journal of Mathematics Education Leadership, 16*(2), 27-37.

Dossey, J. A. (1984). One point of view: Elementary school mathematics specialists: Where are they? *Arithmetic Teacher, 32*(3), 3-50.

Education Week. (2015). *Quality counts.* Retrieved from http://www.edweek.org/media/qualitycounts2015_release.pdf.

EMS & Teacher Leader Project. (2016) [Graph illustration and descriptions by state]. Mathematics Specialist Certification (by State). Retrieved from http://www.mathspecialists.org/state-certifications.html.

Fennel, F. S. (2006). President's message: We need elementary school mathematics specialists NOW. *NCTM News Bulletin, 43*(4), 3.

Gojak, L. (2013). *It's elementary! Rethinking the role of the elementary classroom teacher.* Retrieved from http://www.nctm.org/News-and-Calendar/Messages-from-the-President/Archive/Linda-M_-Gojak/It_s-Elementary!- Rethinking-the-Role-of-the-Elementary-Classroom-Teacher/

Hill, H., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Education Research Journal, 42*, 371-406.

Lott, J. (2003). The time has come for pre-k–5 mathematics specialists, *NCTM News Bulletin, 40*. Retrieved from http://www.nctm.org/about/content.aspx?id=956.

McGatha, M. (2009). *Mathematics specialists and mathematics coaches: What does the research say?*. NCTM Research Briefs. Retrieved from http://nctm.org/uploadedFiles/Research_News_and_Advocacy/Research/Clips_and_Briefs/Research_brief_13_coaches.pdf

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2012). *Elementary math specialist advanced preparation program standards.* Retrieved from http://www.nctm.org/standards-and-positions/caep-standards/.

National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel.* Washington, DC: U.S. Department of Education.

National Research Council. (1989). *Everybody counts: A report to the nation on the future of mathematics education.* Washington, DC: National Academy Press.

National Research Council. (2001). *Adding it up: Helping children learn mathematics.* J. Kilpatrick, J. Swafford, and B. Findell (Eds.). Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

Polly, D. (2012). Supporting mathematics instruction with an expert coaching model. *Mathematics Teacher Education and Development, 14*(1), 78-93.

Race, K. E., Ho, E., & Bower, L. (2002). *Documenting in-classroom support and coaching activities of a professional development program directed toward school-wide change: An integral part of an organization's evaluation efforts.* Paper presented at the annual meeting of the American Education Research Association, New Orleans, LA. Retrieved from http://www.raceassociates.com/materials/AEA2002b.pdf.

Reys, B. J., & Fennell, F. (2003). Who should lead mathematics instruction at the elementary school level? A case for mathematics specialists. *Teaching Children Mathematics, 9*, 277-282.

Rigelman, N. R., & Wray, J. A. (2017). Current state of mathematics specialist state certification and standards. In M. B. McGatha & N. R. Rigelman (Eds.), *Elementary mathematics specialists: Developing, refining, and examining programs that support mathematics teaching and learning.* Charlotte, NC: Information Age Publishing.

Serra, M. (2002). *Discovering geometry* (3rd ed.). Emeryville, CA: Key Curriculum Press.

Smith, M. E., Swars, S. L., Smith, S. Z., Hart, L. C., & Haardoerfer, R. (2012). Effects of an additional mathematics content courses on elementary teachers' mathematical beliefs and knowledge for teaching. *Action in Teacher Education, 4*, 336–348. http://dx.doi.org/10.1080/01626620.2012.712745

Swars, S. L., Smith, S. Z., Smith, M. E., Carothers, J., & Myer, K. (2016). The preparation experiences of elementary mathematic specialists: Examining influences on belief, content knowledge, and teaching practices. *Journal of Mathematics Teacher Education.* Advance online publication. doi: 10.1007/s10857-016-9354-y

Utley, J., & Reeder, S. (2016). Developing leadership capacity: The impact of an elementary mathematics specialists program. Abstract published in *Proceedings of the 39th Annual Meeting of the Psychology of Mathematics Education* – North American Chapter, Tucson, AZ.

Wheatley, G. (2007). *Quick draw* (2nd ed.). Tallahassee, FL: Mathematics Learning.

Wu, H. (2009). What's sophisticated about elementary mathematics. *American Educator, 33*(3), 4-14.

Yackel, E., & Cobb, P. (1996). Sociomathematical norms, argumentation, and autonomy in mathematics. *Journal for Research in Mathematics Education, 27*, 458-477.